TRANSMITTER MOUNTING STRUCTURE FOR TIRE CONDITION MONITORING APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates to a transmitter mounting structure for a tire condition monitoring apparatus, and more specifically, to a transmitter mounting structure for a wireless type tire condition monitoring apparatus enabling tire conditions, such as tire air pressure, to be checked from the passenger compartment of a vehicle.

A transmitter for a tire air pressure monitoring apparatus is mounted on a wheel and located in a tire. A mounting structure of the transmitter includes a valve stem, a spring element, and an electronic module for measuring the air pressure of the tire and transmitting the measured air pressure. The valve stem is coupled to the spring element. The spring element has a clamp plate coupled to the electronic module. The clamp plate clamps the electronic module to the wheel. When the wheel is rotating, various forces, such as centrifugal force, act upon the electronic module. The elastic force of the spring element acts to effectively suppress or control the movement of the electronic module. Accordingly, the electronic module is pressed against a drop center of the wheel when mounted on the wheel (refer to United States Patent No. 5,956,820).

The fastening device described in United States Patent No. 5,956,820, however, cannot cope with all the cross sectional shapes of wheels. That is, there are many types of wheels with different cross sectional shapes, such as, wheels with a drop-center rim, a shallow base rim, a broad flat-base rim, and a broad deep rim. Therefore, the valve stem and the casing which houses the transmitter, and ultimately the mounting angle of the electronic module, is unambiguously determined by the cross sectional shape of the wheel. As a result, in order to mount the electronic module in a state pressed against the drop center

of the wheel, the spring element and clamp plate must be in correspondence to the cross sectional shape of the wheel.

SUMMARY OF THE INVENTION

One aspect of the present invention is a mounting structure for a transmitter of a tire condition monitoring apparatus arranged in a tire of a vehicle having a wheel. The wheel including a drop center and a rim formed integrally with the drop center at a predetermined angle relative to the drop center. The mounting structure includes a valve stem attachable to the rim of the wheel for charging air into the tire. The valve stem has a basal end. The mounting structure further includes a casing connected to the valve stem to house the transmitter and a coupling fixture for coupling the casing and the valve stem. The coupling fixture includes a coupler coupled to the basal end of the valve stem, an anchor for anchoring the casing and a connection for connecting the coupler and the anchor at an angle to one another so that the coupling fixture is resilient. The angle between the coupler and the anchor is greater than the predetermined angle before the coupling fixture couples the casing and the valve stem to one another.

Another aspect of the present invention is a method of mounting a transmitter of a tire condition monitoring apparatus arranged in a tire of a vehicle having a wheel. The wheel includes a drop center and a rim formed integrally with the drop center at a predetermined angle relative to the drop center. The rim has a valve hole. The method includes preparing a valve stem for charging air into a tire, the valve stem having a basal end, preparing a casing for housing the transmitter, the casing having a projection, preparing a coupling fixture for coupling the casing and the valve stem, the coupling fixture including a coupler coupled to the basal end of the valve stem and having a coupling hole, an anchor for anchoring the casing, and a connection for connecting the coupler and the anchor at an angle to one another so that the coupling fixture is resilient, with the angle between the coupler and the anchor being greater than the predetermined angle before the coupling fixture couples the casing and the valve stem, attaching the casing to the anchor of the coupler, inserting the basal end of the

valve stem through a coupling hole of the coupling fixture to couple the basal end of the valve stem to the coupling fixture with a bushing, and attaching the valve stem to the valve hole in the rim when the projection of the casing is abutted against the drop center of the wheel by the resiliency of the coupling fixture.

Other aspects and advantages of the invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention, together with the objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

Fig. 1 is a schematic block diagram showing the structure of a tire condition monitoring apparatus according to a preferred embodiment of the present invention;

Fig. 2 is a cross sectional view of a transmitter mounting structure for the tire condition monitoring apparatus in the preferred embodiment of the present invention;

Fig. 3 is a plan view of the transmitter of the tire condition monitoring apparatus of **Fig. 2**;

Fig. 4(a) is a plan view showing a plate spring used in the mounting structure of **Fig. 2**, and **Fig. 4(b)** is a cross sectional view of the plate spring of **Fig. 4(a)**;

Fig. 5 is a perspective view showing a bracket used in the mounting structure of **Fig. 2**;

Fig. 6 is a cross sectional view showing the state of a casing for the transmitter mounting structure of the tire condition monitoring apparatus when the vehicle velocity is less than a first speed; and

Fig. 7 is a cross sectional view showing the state of the casing of **Fig. 6** when the vehicle velocity is greater than or equal to a second speed.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the drawings, like numerals are used for like elements throughout.

Fig. 1 is a schematic diagram of a tire condition monitoring apparatus, which includes a transmitter mounting structure according to a preferred embodiment of the present invention. As shown in **Fig. 1**, the tire condition monitoring apparatus **1** includes four transmitters **30**, each arranged in each tire **20** of a vehicle **10**, and a receiver **40** arranged in the body **11** of the vehicle **10**.

Each transmitter **30** is fixed to the interior of the corresponding tire **20**, for example, to the wheel **21** of the tire **20**. The transmitter **30** measures conditions of the tire **20**, such as the tire pressure in the corresponding tire **20**, and transmits the data including the tire pressure data obtained through the measurement in a wireless manner.

The receiver **40** is located at a predetermined position on the body **11** and operated, for example, by electric power from a vehicle battery (not shown). The receiver **40** has a receiving antenna **41**, which is connected to the receiver **40** by a cable **42**. The receiver **40** receives data transmitted from each transmitter **30** through the receiving antenna **41**. A display **50** is arranged within the visual range of the driver of the vehicle **10** in the vehicle compartment. The display **50** is connected to the receiver **40** by a cable **43**.

As shown in **Fig. 2**, a connection concavity **61** is formed along the circumferential direction at the basal end of a valve stem **60**, which is arranged in the tire **20**. A rubber grommet **62** is fitted in the connection concavity **61**. The rubber grommet **62** is pressed against the wall defining a valve hole **22** extending through the wheel **21**. A valve nut **63** is engaged with the valve stem **60** from the outer side of the wheel **21** to fasten the valve stem **60** to the wheel **21**. As a result, the rubber grommet **62** hermetically seals the tire **20**.

A plate spring (coupling fixture) **70** is connected to the basal end of the valve stem **60**. A bushing **64** is press-fitted into the basal end of the valve stem **60** to connect the valve stem

60 and the plate spring **70**. A casing **80**, which houses the transmitter **30**, and a bracket **90** are attached to the plate spring **70**. A projection **81** extends from the bottom surface of the casing **80**. The resiliency of the plate spring **70** abuts the projection **81** against a drop center **23** of the wheel **21**.

As shown in **Fig. 3**, side walls **64a** extend from opposite sides of the bushing **64**. A through hole **64b** extends through the center of the bushing **64**. Air is charged into the tire from the valve stem **60** and through the through hole **64b**. A valve cap **65** is engaged with the distal end of the valve stem **60**.

Referring to **Figs. 4(a) and 4(b)**, the plate spring **70** is resilient and formed, for example, by bending a thin metal piece until its cross section becomes U-shaped. The plate spring **70** includes a coupler **73** coupled to the basal end of the valve stem **60**. A coupling hole **71** extends through the coupler **73**. The plate spring **70** also includes an anchor **74**, which is anchored to the casing **80**, and a connection **75**, which connects the coupler **73** and the anchor **74**. Two anchor holes **72** extend through the anchor **74**. The connection **75** connects the coupler **73** and the anchor **74** so that the plate spring **70** is resilient. More specifically, the connection **75** is bent so as to have a predetermined curvature **R**, as shown in **Fig. 4(b)**.

As shown in **Fig. 4(b)**, the angle θ**2** formed between the coupler **73** and the anchor **74** before the plate spring **70** is attached to the valve stem **60** is greater than the angle θ**1** formed between the coupler **73** and the anchor **74** after the plate spring **70**. The reason for this is to cope with the various cross sectional shapes a wheel **21** may have. For example, the plate spring **70** may be employed even when the rim angle (second predetermined angle) θ**r** formed between a drop center **23** of the wheel **21** and a rim **24** of the wheel **21** is larger than angle θ**1** (first predetermined angle), as shown in **Fig. 6**. More specifically, before the plate spring **70** is attached to the valve stem **60**, the angle θ**2** formed between the coupler **73** and

the anchor **74** is set so as to be greater than the angle $\theta\mathbf{1}$ and the angle $\theta\mathbf{r}$.

As shown in **Fig. 5**, a bracket **90** is provided with two rotation regulating walls **91** for regulating the rotation of the plate spring **70**. The rotation regulating walls **91** abut against the side walls **64a** of the bushing **64** when the valve stem **60** is inserted through the valve hole **22**. As shown in **Fig. 3**, the two rotation regulating walls **91** are formed so as to sandwich the side walls **64a** of the bushing **64**. Two anchor holes **92** extend through the bracket **90**. The anchor holes **92** correspond to the two anchor holes **72** of the plate spring **70**.

As shown in **Fig. 2**, two protrusions **82** extend from the top surface of the casing **80**. The protrusions **82** project through the anchor holes **92** of the bracket **90** and the anchor holes **72** of the plate spring **70**. The projected part of each protrusion **82** is heated and deformed into a rivet shape. This fixes the casing **80** to the plate spring **70** and the bracket **90**.

A method for arranging the valve stem **60** in the valve hole **22** of the wheel **21** will now be described.

As shown in **Fig. 6**, when the casing **80** is fixed to the plate spring **70** and the bracket **90**, the bushing **64** is inserted through the coupling hole **71** of the plate spring **70**. Then, the bushing **64** is press fitted to the basal end of the valve stem **60** to connect the basal end of the valve stem **60** to the plate spring **70**.

Subsequently, in a state in which the valve nut **63** and the cap **65** are removed, the valve stem **60** is inserted through the valve hole **22** from the inner side of the wheel **21**. Then, the valve nut **63** is threadably engaged with the valve stem **60** from the outer side of the wheel **21** to attach the valve stem **60** to the wheel **21**. At this time, the plate spring **70**, which is coupled to the basal end of the valve stem **60**, tends to rotate in the turning direction of the valve nut **63** when threading the valve nut **63** on to the valve stem **60**. However, as shown in **Fig. 3**, the side walls **64a** of the bushing **64**, which is pressed fitted into the basal

end of the valve stem **60**, abuts against the rotation regulating walls **91** of the bracket **90**. Further, as shown in **Fig. 6**, the bracket **90** is fixed to the plate spring **70** by the pair of protrusions **82** of the casing **80**.

The projection **81** extending from the bottom surface of the casing **80** is abutted against the drop center of the wheel **21** by the resiliency of the plate spring **70**. Therefore, the side walls **64a** of the bushing **64** abuts against the rotation regulating walls **91** and regulates the rotation of the plate spring **70** even when the plate spring **70** tends to rotate in the rotation direction of the valve nut **63** when screwing the valve nut **63** on to the valve stem **60**. As a result, the plate spring **70** does not rotate in the rotation direction of the valve nut **63** when the valve nut **63** is threaded on to the valve stem **60**. Accordingly, the valve stem **60** is attached to the wheel **21** in a state in which the projection **81** of the casing **80** is abutted against the drop center **23** of the wheel **21**.

Centrifugal force acts on the casing **80** when the vehicle **10** is moving. The centrifugal force increases in proportion to the velocity of the vehicle **10**. Therefore, when the velocity of the vehicle **10** reaches a first velocity (for example, 40 km/h), the centrifugal force becomes greater than the resiliency of the plate spring **70**. As a result, when the vehicle **10** is moving at the first velocity or faster, the projection **81** of the casing **80** moves away from the drop center **23** of the wheel **21**.

When the vehicle **10** reaches a second velocity (for example, 80 km/h), which is greater than the first speed, distal portions **91a** of the rotation regulating walls **91** abut against the coupler **73** of the plate spring **70**, as shown in **Fig. 7**. This restricts further movement of the casing **80** from the drop center **23** of the wheel **21** even when the velocity becomes greater than the second speed. As a result, the resiliency of the plate spring **70** is maintained. When the velocity of the vehicle **10** becomes less than the first velocity, the projection **81** of the casing **80** abuts against the drop center **23** of the wheel **21** again, as

shown in **Fig. 6**.

When the vehicle **10** is not moving or when changing the tire **20**, the projection **81** of the casing **80** is abutted against the drop center **23** of the wheel **21**. Thus, when changing the tire **20**, the bead of the tire **20** does not hit the bracket **90**. This prevents the casing **80**, which houses the transmitter **30**, from being damaged. When the vehicle is moving at a velocity that is greater than or equal to the first velocity, the projection **81** of the casing **80** is moved away from the drop center **23** of the wheel **21**. This lessens the influence of the wheel **21** on radio waves transmitted from the transmitter **30**. That is, since the casing **80** which houses the transmitter **30** becomes more distant from the wheel **21**, which is generally formed of metal, the radio waves transmitted from the transmitter **30** are less affected by the wheel **21**. Thus, the reception sensitivity of the receiver **40** improves when the vehicle is moving at a velocity that is greater than or equal to the first speed. Accordingly, the receipt of data transmitted from the transmitter **30** by the receiver **40** through the receiving antenna **41** is ensured.

The transmitter mounting structure for a tire condition monitoring apparatus of the present embodiment has the advantages described below.

(1) The angle θ2 (refer to **Fig. 4(b)**) formed by the coupler **73** and the anchor **74** of the plate spring **70** before the plate spring **70** is attached to the valve stem **60** is set so as to be greater than the maximum rim angle θ**r** (refer to **Fig. 6**) formed between the drop center **23** of the wheel **21** and the rim **24** of the wheel **21**. Therefore, when the valve stem **60** coupled to the plate spring **70** is attached to the wheel **21**, the projection **81** of the casing **80** is abutted against the drop center **23** of the wheel **21**. Accordingly, the transmitter **30** may be attached to the wheel **21** regardless of the cross sectional shape of the wheel **21**. Thus, when the casing **80** is abutted against the drop center **23** of the wheel **21**, the valve stem **60** is attached to the wheel **21** regardless of the cross sectional shape of the wheel **21**.

(2) The two rotation regulating walls **91** extending from the bracket **90** abut against the side walls **64a** of the bushing **64** when the valve stem **60** is arranged in the valve hole **22** of the wheel **21** to regulate the rotation of the plate spring **70**. The side walls **64a** of the bushing **64** are located between the two rotation regulating walls **91** to abut against the rotation regulating walls **91**. Therefore, the rotation of the plate spring **70** is regulated even when the plate spring **70** tends to rotate in the rotation direction of the valve nut **63** when threading on the valve nut **63** on the valve stem **60**. As a result, the plate spring **70** does not rotate in the rotation direction of the valve nut **63** when the valve nut **63** is threaded on to the valve stem **60**. Accordingly, the abutment of the projection **81** of the casing **80** against the drop center **23** of the wheel **21** enables the attachment of the valve stem **60**.

(3) When the velocity of the vehicle **10** attains a second velocity (for example, 80 km/h) greater than the first velocity (for example, 40 km/h), the distal portions **91a** of the rotation regulating walls **91** abut against the coupler **73** of the plate spring **70**, as shown in **Fig. 7**. Therefore, the casing **80** does not separate from the drop center **23** of the wheel **21** even when the vehicle moves at a velocity greater than the second speed. As a result, the elastic return force of the plate spring **70** is maintained. When the velocity of the vehicle **10** decreases to below the first speed, the projection **81** of the casing **80** abuts the drop center **23** of the wheel **21**.

(4) Since the electronic module (casing **80**) is arranged in a state pressed against the drop center of the wheel **21**, a spring element and a clamp plate conforming to the cross sectional shape of a wheel, as described in United States Patent No. 5,956,820, are unnecessary. This reduces the number of parts and facilitates the management of such parts when manufacturing the device. Accordingly, parts are assembled together more efficiently and manufacturing efficiency is improved.

It should be apparent to those skilled in the art that the present invention may be

embodied in many other specific forms without departing from the spirit or scope of the invention. Particularly, it should be understood that the invention may be embodied in the following forms.

The relationship between the bushing **64**, which is provided with the side walls **64a** and press fitted to the basal end of the valve stem **60**, and the regulating walls **91**, which extend from the bracket **90**, may be reversed. That is, the rotation regulating walls may be formed on the bushing **64**, and side walls corresponding to the rotation regulating walls may be formed on the bracket **90**.

The present invention may be embodied in any type of vehicle that uses a tire **20**, such as a four-wheeled vehicle, a two-wheeled vehicle, a bus, or a truck.

The present examples and embodiments are to be considered as illustrative and not restrictive and the invention is not to be limited to the details given herein, but may be modified within the scope and equivalence of the appended claims.